(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 934 013 B2

(12) NEW EUROPEAN PATENT SPECIFICATION
After opposition procedure

(45) Date of publication and mention of the opposition decision:
11.05.2022 Bulletin 2022/19

(45) Mention of the grant of the patent:
11.11.2015 Bulletin 2015/46

(21) Application number: **06806063.1**

(22) Date of filing: **05.10.2006**

(51) International Patent Classification (IPC):
B23K 35/28 (2006.01) ***B32B 15/01*** (2006.01)
B23K 35/02 (2006.01)

(52) Cooperative Patent Classification (CPC):
B32B 15/016; B23K 35/0238; B23K 35/286

(86) International application number:
PCT/EP2006/009654

(87) International publication number:
WO 2007/042206 (19.04.2007 Gazette 2007/16)

(54) MULTI-LAYERED BRAZING SHEET

VIELSCHICHTIGES HARTLÖTUNGSBLATT

BRASAGE DE FEUILLE MULTICOUCHE

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **13.10.2005 EP 05077343**

(43) Date of publication of application:
25.06.2008 Bulletin 2008/26

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Description

[0001] The invention relates to an aluminium brazing sheet to be used in heat exchanger systems, such as for instance heat exchangers for automotive purposes. Ideally the brazing sheet is used for manufacturing tubes of such a heat exchanger.

[0002] The known brazing sheets for this purpose usually consist of a three layer system comprising an outer 4xxx alloy clad, a 3xxx core alloy and a 7xxx or 1xxx innerliner alloy. In this specific application the inside wall of the successive parts of the heat exchanger is in direct contact with the cooling fluid and because of the temperature of said fluid and the flow conditions a high corrosion resistance is required. It is well known to use a Zn containing innerliner to improve the corrosion resistance of these brazing sheets. Common innerliners are made of for example a 7072 alloy or a 3003 alloy with Zn. The Zn containing innerliners act as sacrificial anode, forcing the corrosion to attack the inner surface of the heat exchanger in a lateral way instead of penetrating the layer by localized pitting or intergranular corrosion.

[0003] As will be appreciated alloy designations and temper designations, except otherwise indicated, refer to the Aluminum Association designations in Aluminum Standards and Data and the Registration Records, all published by the US Aluminum Association.

[0004] All percentages are in weight percent, unless otherwise indicated.

[0005] The brazing sheet disclosed in to EP-1351795 has an innerliner with 1.3-1.5 wt% Zn and, among others < 0.4 wt% Si and 0.05-0.4 wt% Cu. Also in WO 02/055256 a 2 or 3 layer sheet is disclosed with a core of a 3xxx alloy and an innerliner with, among others, 0.7 - 3.0 wt% Zn. In JP-11293372 high corrosion resistance is disclosed for a system with a 2 or 3 layer system with a core consisting among others, 0.3 - 1.1 wt% Si, clad on one or both sides with sacrificial anode material consisting of, among others, 1.5 - 8 wt% Zn with Fe and Si compounds regulated. From EP-1391679 a sacrificial waterside liner to be used in a heat exchanger is known with 1.0 - 10.0 wt% Zn but also, among others, 0.4 -3.0 wt% Ni.

[0006] US6911267B1 discloses a brazing sheet comprising an aluminum 3xxx series core alloy wherein at least one side thereof is provided with an aluminum clad material comprising from 0.7-2.0% Mn and 0.7-3.0% Zn, wherein said clad is capable of being used as the innerliner of a heat exchanger tube product; one side of said core is provided with a material that comprises from 0.7-2.0% Mn and 0.7-3.0% Zn and the other side of said core is provided with an aluminium alloy comprising at least 5.5% Si. The core can be provided with one or two layered clad materials. An innerliner is provided between the core and the braze cladding.

[0007] An object of the invention is to provide an aluminium multi-layered brazing sheet product to be used in heat exchanger applications with an improved long life corrosion resistance with respect to the known multi-layer systems.

[0008] This object is achieved by having an interliner provide effective sacrificial protection of the core by carefully balancing the content of alloying elements in the interliner and core, that influence the corrosion potential, taking into account diffusion during processing and brazing of the sheet. The more important alloying elements to control are Zn and Cu and to a lesser extent Si, Mn, and Mg.

[0009] Accordingly a multilayered brazing sheet is provided according to claim 1.

[0010] With the above composition the required electrochemical potential profile for sacrificial protection is provided for with the core having the highest corrosion potential. According to tests a difference in corrosion potential between interliner and core after brazing should be at least 20mV and preferably 30mV.

[0011] After brazing, the braze liner will be almost disappeared because it flows away. However, during the processing of the material, and the heat up phase of the brazing cycle, a diffusion layer between braze liner and inter liner will have been formed. The additional difference in corrosion potential, caused by the presence of this diffusion layer on top of the inter liner is used to enhance the sacrificial protection. So the inner braze cladding not only has the advantage to be able to braze the brazing sheet product on the inside, but it also provides a significant contribution to the sacrificial protection.

[0012] According to a preferred embodiment the 3xxx alloy of the core preferably comprises < 0.5 wt% Fe in order to have good formability of the alloy.

[0013] According to a preferred embodiment the 3xxx alloy of the core preferably comprises 0.55 - 0.8 wt% Cu. By adding Cu to the core, the corrosion potential is increased, as far as the Cu stays in solid solution. To get the required relatively high corrosion potential of the core a minimum Cu level of 0.55% is necessary. Above 1% Cu the solidus temperature of the core becomes to close to the brazing temperature which would make the alloy no longer suitable for brazing. The preferred upper limit for Cu is 0.8% to avoid a relatively high Cu content in the interliner due to diffusion from the core into the interliner.

[0014] According to a preferred embodiment the 3xxx alloy of the core preferably comprises 0.65 - 1.5 wt% Mn and more preferably 0.65 - 1.2 wt% Mn. Below 0.65% Mn the strength of the alloy is too low, above 1.5% Mn the danger for coarse intermetallics, that can be formed during casting, increases considerably. In combination with the presence of up to 0.7%Fe, the preferred upper limit is 1.2%Mn to be on the safe side for casting problems due to coarse intermetallics.

[0015] The 3xxx alloy of the core comprises < 0.05% Mg. Mg increases the strength of the alloy significantly, but in

Controlled Atmosphere Brazing, the presence of Mg can poison the flux. Mg can relatively easy diffuse from the core into the clad.

[0016] According to a preferred embodiment the 3xxx alloy of the core preferably comprises < 0.15 wt% Cr. Cr in a range up to 0.3% can be added to the alloy to improve the strength in the post braze condition. However to avoid problems with intermetallics during casting, the preferred upper limit is 0.15%.

[0017] According to a preferred embodiment the 3xxx alloy of the interliner preferably comprises < 0.7 wt% Si and more preferably 0.4 wt% Si. The maximum level of Si is 1% to avoid a low solidus temperature. However, in combination with the other elements that can also reduce the solidus temperature, the preferred Si level is kept lower.

[0018] According to a preferred embodiment the 3xxx alloy of the interliner preferably comprises < 0.5 wt% Fe. The same reasons apply as given for Fe content in the core alloy.

[0019] According to a preferred embodiment the 3xxx alloy of the interliner preferably comprises < 0.2 wt% Cu. This is an important alloying element according to the invention, but in the interliner the level of Cu should be limited because it will increase the corrosion potential. Since the interliner should have a relatively low corrosion potential, the level of Cu is preferably limited to <0.2%.

[0020] The 3xxx alloy of the interliner comprises 0.5 - 1.0 wt% Mn. In order to keep the right balance in corrosion potential between core and interliner, there is less Mn in the interliner than in the core.

[0021] According to a preferred embodiment the 3xxx alloy of the interliner preferably comprises < 0.1 wt% Mg. The same reasons apply as given for the Mg content in the core alloy.

[0022] According to a preferred embodiment the 3xxx alloy of the interliner preferably comprises 0.5 - 3.0 wt% Zn. This is an important alloying element according to the invention. By adding Zn to the interliner, the corrosion potential can be decreased. To get the required relatively low corrosion potential of the interliner a minimum Zn level of 0.1% is necessary. Above 5%Zn the difference in corrosion potential between core and interliner becomes too high, resulting in rapid self corrosion of the system. For the right balance between core and interliner the preferred Zn range is 0.5-3.0%.

[0023] The brazing sheet preferably has on the opposite side of the core an outer braze cladding such that the multi layered brazing sheet product consists of a four layered system. The inner braze cladding as well as the outer braze cladding are preferably made of a 4xxx alloy with <15 wt% Si, preferably 4 - 15 wt% and more preferable 7-12 wt% Si and Cu < 0.3 wt%. Any braze clad which melts just below the brazing temperature will be suited, as long as it does not interfere with the corrosion potential balance. To avoid any interference with the corrosion potential balance, the braze clad should not contain more than 0.3%Cu, or more than 0.2%Zn. Well known braze alloys like AA4045 and AA4343 are suited.

[0024] The brazing sheet may comprise 3, 4 or 5 layers, the three layered sheet having a core, interliner and braze cladding at the inner side; the four layered sheet having an outer braze cladding and the five layered sheet having also an interliner between the core and the outer braze cladding. With the inner braze cladding it become also possible to braze the brazing sheet product on the inside. For example dividing a tube in two tubes by bringing opposite parts of the inner side of said tube against each other and connect these parts by brazing, the so called B-type tubes.

[0025] The successive layers of the multi-layer brazing sheet preferably have a thickness ratio in respect to the total thickness of the multi-layered brazing sheet of:

- outer clad 05 - 15%
- core 60 - 85 %
- interliner 05 - 30 %
- innerside clad 05 - 15 %.

[0026] Furthermore, the invention also includes a brazed assembly comprising one or more tubes made from the multi-layered brazing sheet product.

EXAMPLES

Example 1

[0027] The following 4-layer brazing sheet was produced:

Braze clad: 10% of thickness.
Standard 4343 (with 0.25%Fe and 0.015%Cu)
Core: 70% of thickness
Nominal chemistry:

Si: 0.15%

Fe: 0.35%

Cu: 0.65%

Mn: 0.95%

Mg: 0.01%

Cr: 0.03%

Zn: 0.02%

Ti: 0.09%

Zr: 0.03%

Interliner: 15% of thickness
Nominal chemistry:

Si: 0.15%
Fe: 0.25%
Cu: 0.02%
Mn: 0.90%
Mg: 0.01%
Zn: 1.2%
Ti: 0.03%

Braze clad: 5% of thickness.
Standard 4343 (with 0.25%Fe and 0.015%Cu)

[0028] The different layers were combined by roll bonding, in the same way as a standard 3-layer brazing material is produced. It was rolled down to a final thickness of 0.260 mm. Next, the material was given a brazing simulation: heat up with 25 °C/min to 600°C, hold for 6 minutes and cooled down with 25 °C/min. The sample was hanging, so the molten braze clad layers were flown to the bottom of the sample, leaving only a thin layer of residual clad at the surface of the sample.

[0029] The corrosion potential profile was measured up to a depth of 0.08 mm.

[0030] The result is shown in fig.1. It can be concluded that for this sample the difference in corrosion potential between core and interliner is about 42 mV, and between core and surface about 50 mV. These differences in corrosion potential are highlighted in fig. 2.

Example 2

[0031] Three 4-layer brazing sheet materials were produced. The nominal chemistries of the alloys used for these materials were identical, except for the Zn level in the interliner. The nominal Zn level in the interliner was 1.2%, 2.5% and 4.5% respectively.

[0032] All three materials have an AA4343 (with 0.25%Fe and 0.015%Cu) braze clad of 10% of the thickness, on one side of the core. On the other side is an interliner, 15% of the thickness, followed by an AA4343 (with 0.25%Fe and 0.015%Cu) braze clad, 5% of the thickness.

[0033] The different layers were combined by roll bonding, in the same way as a standard 3-layer brazing material is produced. All three materials were rolled down to a final thickness of 0.260 mm. Next, the materials were given a brazing simulation: heat up with 25 °C/min to 600°C, hold for 6 minutes and cooled down with 25 °C/min. The samples were hanging, so the molten braze clad layers were flown to the bottom of the sample, leaving only a thin layer of residual clad at the surface of the sample.

1) Material with nominal 1.2% Zn in the interliner

See example 1.

2) Material with nominal 2.5% Zn in the interliner

Core: 70% of thickness

[0034] Actual chemistry of this material is identical to the material with 1.2%Zn in the interliner, as material from the same cast was used:

Si: 0.17%
Fe: 0.30%
Cu: 0.65%
Mn: 0.88%
Mg: 0.006%
Cr: 0.03%
Zn: 0.01%
Ti: 0.095%
Zr: 0.03%

Interliner: 15% of thickness
Actual chemistry:

Si: 0.04%
Fe: 0.14%
Cu: 0.00%
Mn: 0.8%
Mg: 0.00%
Zn: 2.61 %
Ti: 0.03%

[0035] The corrosion potential profile was measured up to a depth of 0.08 mm (80 μm). The result is shown in figure 2. It can be concluded that for this example that the difference in corrosion potential between core and interliner is about 60 mV, and between core and surface about 70 mV.

3) Material with nominal 4.5% Zn in the interliner

[0036]

Core: 70% of thickness
Actual chemistry:

Si: 0.10%
Fe: 0.28%
Cu: 0.62%
Mn: 0.89%
Mg: 0.006%
Cr: 0.03%
Zn: 0.01%
Ti: 0.098%
Zr: 0.02%

Interliner: 15% of thickness
Actual chemistry:

Si: 0.04%
Fe: 0.18%

Cu: 0.00%
Mn: 0.85%
Mg: 0.01%
Zn: 4.43%
Ti: 0.03%

[0037] The corrosion potential profile was measured up to a depth of 0.08 mm (80 μm). The result is also shown in figure 2. It can be concluded that for this example that the difference in corrosion potential between core and interliner is about 115 mV, and between core and surface about 145 mV.

[0038] The results in figure 2 show the effect of an increasing amount of Zn in the interliner.

Example 3

[0039] Another 4-layer brazing sheet material was produced, with nominal Zn level in the interliner 4.5%.

[0040] The chemistry of the core and interliner used for this new material is identical to the one used in example 2 (third material), as materials from the same casts were used.

[0041] The difference with the material from example 2 is the thickness of the interliner, which is 20% of the thickness for the current material.

[0042] The material has an AA4343 (with 0.25%Fe and 0.015%Cu) braze clad of 10% of the thickness, on one side of the core. On the other side is an interliner, 20% of the thickness, followed by an AA4343 (with 0.25%Fe and 0.015%Cu) braze clad, 5% of the thickness.

[0043] The different layers were combined by roll bonding, in the same way as a standard 3-layer brazing material is produced. The material was rolled down to a final thickness of 0.260 mm. heat up with 25 °C/min to 600°C, hold for 6 minutes and cooled down with 25 °C/min. The sample was hanging, so the molten braze clad layers were flown to the bottom of the sample, leaving only a thin layer of residual clad at the surface of the sample.

[0044] The corrosion potential profile was measured up to a depth of 0.08 mm (80 μm).

[0045] The result is shown in figure 3. It can be concluded that for this example that the difference in corrosion potential between core and interliner is about 190 mV, and between core and surface about 225 mV.

[0046] The results in figure 4 show the effect of an increasing thickness of the interliner.

[0047] The results shown in the different examples, can be summarized as follows:

% Zn in Interliner	Thickness of Interliner (μm)	Corrosion potential difference between core and Interliner (mV)	Corrosion potential difference between core and surface (mV)
1.2	39	42	50
2.5	39	60	70
4.5	39	115	145
4.5	52	190	225

Claims

1. A multi-layer brazing sheet comprising:

- a core of a 3xxx alloy
- an inner braze cladding of a 4xxx alloy, and
- between core and inner braze cladding an interliner of a 3xxx alloy, and

wherein the 3xxx alloy of the core consists of:

- 0.55 - 1.0 wt.% Cu
- 0.65 - 1.8 wt.% Mn
- < 0.05 wt.% Mg
- < 0.4 wt.% Zn
- < 1.0 wt.% Si
- < 0.7 wt.% Fe

and optionally one or more of

- < 0.3 wt.% Cr
- < 0.2 wt.% Ti,

and one or more of V, Zr, In, Sc, Sn, each in a range of up to 0.5 %, balance aluminium and unavoidable impurities, and
wherein the 3xxx alloy of the interliner consists of:

- < 0.25 wt.%Cu
- 0.5 - 1.0 wt.% Mn
- < 0.3 wt.% Mg
- 0.1 - 5.0 wt.% Zn
- < 1.0 wt.% Si
- < 0.7 wt.% Fe

balance aluminium and unavoidable impurities, wherein the interliner has less Mn than the core.

2. A brazing sheet according to claim 1, wherein the 3xxx alloy of the core preferably comprises:

- < 0.5 wt.% Fe.

3. A brazing sheet according to any one of claims 1-2, wherein the 3xxx alloy of the core preferably comprises:

- 0.55 - 0.8 wt.% Cu.

4. A brazing sheet according to any one of claims 1-3, wherein the 3xxx alloy of the core preferably comprises:

- 0.65 - 1.5 wt.% Mn and more preferably 0.65 - 1.2 wt.% Mn.

5. A brazing sheet according to any one of claims 1-4, wherein the 3xxx alloy of the core preferably comprises:

- < 0.15 wt.% Cr.

6. A brazing sheet according to any one of claims 1-5, wherein the 3xxx alloy of the interliner preferably comprises: < 0.7 wt.% Si and more preferably 0.4 wt.% Si.

7. A brazing sheet according to any one of claims 1-6, wherein the 3xxx alloy of the interliner preferably comprises:

- < 0.5 wt.% Fe.

8. A brazing sheet according to any one of claims 1-7, wherein the 3xxx alloy of the interliner preferably comprises:

- < 0.2 wt.% Cu.

9. A brazing sheet according to any one of claims 1-8, wherein the 3xxx alloy of the interliner preferably comprises:

- < 0.1 wt.% Mg.

10. A brazing sheet according to any one of claims 1-9, wherein the 3xxx alloy of the interliner preferably comprises:

- 0.5 - 3.0 wt.% Zn.

11. A brazing sheet according to any one of claims 1-10, wherein the brazing sheet further comprises an outer brazing cladding.

12. A brazing sheet according to claim 11, wherein a further interliner is provided for between the core and outer brazing cladding.

13. A brazing sheet according to claim 11 or 12, wherein the inner and/or outer braze cladding is made of a 4xxx alloy with Si < 15 wt.%, preferably Si < 4 - 15 wt.% and with Cu < 0.3 wt.%.

14. A brazing sheet according to any one of claims 1-13, wherein successive layers of the brazing sheet with respect to the total thickness of the multi-layered brazing sheet have the following thickness ratio:

outer clad	5 - 15 %
core	60 - 85 %
interliner	5 - 30%
innerside clad	5 - 15 %.

15. Brazed assembly comprising one or more tubes made from the multi-layered brazing sheet product according to any one of claims 1-13.

Patentansprüche

1. Mehrschichtiges Hartlötblech, umfassend:

- einen Kern aus einer 3xxx-Legierung
- eine innere Hartlötplattierung aus einer 4xxx-Legierung, und
- zwischen dem Kern und der inneren Hartlötplattierung eine Zwischenauskleidung aus einer 3xxx-Legierung, und wobei die 3xxx-Legierung des Kerns besteht aus:

  - 0,55 - 1,0 Gew.-% Cu
  - 0,65 - 1,8 Gew.-% Mn
  - < 0,05 Gew.-% Mg
  - < 0,4 Gew.-% Zn
  - < 1,0 Gew.-% Si
  - < 0,7 Gew.-% Fe

  und optional einem oder mehreren von

    - < 0,3 Gew.-% Cr
    - < 0,2 Gew.-% Ti

  und einem oder mehreren von V, Zr, In, Sc, Sn, je in einem Bereich von bis zu 0,5%, Rest Aluminium und unvermeidliche Verunreinigungen,
  und wobei die 3xxx-Legierung der Zwischenauskleidung besteht aus:

    - < 0,25 Gew.-% Cu
    - 0,5 - 1,0 Gew.-% Mn
    - < 0,3 Gew.-% Mg
    - 0,1 - 5,0 Gew.-% Zn
    - < 1,0 Gew.-% Si
    - < 0,7 Gew.-% Fe

  Rest Aluminium und unvermeidliche Verunreinigungen, wobei die Zwischenauskleidung weniger Mn als der Kern aufweist.

2. Hartlötblech nach Anspruch 1, wobei die 3xxx-Legierung des Kerns vorzugsweise umfasst:

- < 0,5 Gew.-% Fe.

3. Hartlötblech nach einem der Ansprüche 1-2, wobei die 3xxx-Legierung des Kerns vorzugsweise umfasst:

- 0,55 - 0,8 Gew.-% Cu.

4. Hartlötblech nach einem der Ansprüche 1-3, wobei die 3xxx-Legierung des Kerns vorzugsweise umfasst:

   - 0,65 - 1,5 Gew.-% Mn und bevorzugter 0,65 -1,2 Gew.-% Mn.

5. Hartlötblech nach einem der Ansprüche 1-4, wobei die 3xxx-Legierung des Kerns vorzugsweise umfasst:

   - < 0,15 Gew.-% Cr.

6. Hartlötblech nach einem der Ansprüche 1-5, wobei die 3xxx-Legierung der Zwischenauskleidung vorzugsweise umfasst:

   - < 0,7 Gew.-% Si und bevorzugter 0,4 Gew.-% Si.

7. Hartlötblech nach einem der Ansprüche 1-6, wobei die 3xxx-Legierung der Zwischenauskleidung vorzugsweise umfasst:

   - < 0,5 Gew.-% Fe.

8. Hartlötblech nach einem der Ansprüche 1-7, wobei die 3xxx-Legierung der Zwischenauskleidung vorzugsweise umfasst:

   - < 0,2 Gew.-% Cu.

9. Hartlötblech nach einem der Ansprüche 1-8, wobei die 3xxx-Legierung der Zwischenauskleidung vorzugsweise umfasst:

   - < 0,1 Gew.-% Mg.

10. Hartlötblech nach einem der Ansprüche 1-9, wobei die 3xxx-Legierung der Zwischenauskleidung vorzugsweise umfasst:

   - 0,5 - 3,0 Gew.-% Zn.

11. Hartlötblech nach einem der Ansprüche 1-10, wobei das Hartlötblech ferner eine äußere Hartlötplattierung umfasst.

12. Hartlötblech nach Anspruch 11, wobei eine weitere Zwischenauskleidung zwischen dem Kern und der äußeren Hartlötplattierung vorgesehen ist.

13. Hartlötblech nach Anspruch 11 oder 12, wobei die innere und/oder äußere Hartlötplattierung aus einer 4xxx-Legierung mit Si < 15 Gew.-%, vorzugsweise Si < 4 - 15 Gew.-%, und mit Cu < 0,3 Gew.-% besteht.

14. Hartlötblech nach einem der Ansprüche 1-13, wobei aufeinanderfolgende Schichten des Hartlötblechs bezüglich der Gesamtdicke des mehrschichtigen Hartlötblechs das folgende Dickenverhältnis aufweisen:

äußere Plattierung	5 - 15%
Kern	60 - 85%
Zwischenauskleidung	5 - 30%
innere Plattierung	5 - 15%.

15. Hartgelötete Anordnung, die ein oder mehrere Rohre aus dem mehrschichtigen Hartlötblechprodukt nach einem der Ansprüche 1 bis 13 umfasst.

Revendications

1. Feuille de brasage multicouches comprenant :

- une âme en alliage de type 3xxx
- un revêtement de brasage intérieur en alliage de type 4xxx, et
- entre l'âme et le revêtement de brasage intérieur, un doublage intermédiaire d'un alliage de type 3xxx, et dans lequel l'alliage de type 3xxx de l'âme est constitué de :

  - 0,55 à 1,0 % en poids de Cu
  - 0,65 à 1,8 % en poids de Mn
  - < 0,05 % en poids de Mg
  - < 0,4 % en poids de Zn
  - < 1,0 % en poids de Si
  - < 0,7 % en poids de Fe

  et en option un ou plusieurs de

    - < 0,3 % en poids de Cr
    - < 0,2 % en poids de Ti,

  et un ou plusieurs parmi V, Zr, In, Sc, Sn, chacun dans une plage allant jusqu'à 0,5 %, le reste étant de l'aluminium et des impuretés inévitables,
  et
  dans laquelle l'alliage de type 3xxx du doublage intermédiaire est constitué de :

    - < 0,25 % en poids de Cu
    - 0,5 à 1,0 % en poids de Mn
    - < 0,3 % en poids de Mg
    - 0,1 à 5,0 % en poids de Zn,
    - < 1,0 % en poids de Si
    - < 0,7 % en poids de Fe

  le reste étant de l'aluminium et des impuretés inévitables, dans laquelle le doublage intermédiaire comprend moins de Mn que l'âme.

2. Feuille de brasage selon la revendication 1, dans laquelle l'alliage de type 3xxx de l'âme comprend de préférence :

- < 0,5 % en poids de Fe.

3. Feuille de brasage selon l'une quelconque des revendications 1 et 2, dans laquelle l'alliage de type 3xxx de l'âme comprend de préférence :

- 0,55 - 0,8 % en poids de Cu.

4. Feuille de brasage selon l'une quelconque des revendications 1 à 3, dans laquelle l'alliage de type 3xxx de l'âme comprend de préférence :

- 0,65 - 1,5 % en poids de Mn et de manière plus préférée de 0,65 à 1,2 % en poids de Mn.

5. Feuille de brasage selon l'une quelconque des revendications 1 à 4, dans laquelle l'alliage de type 3xxx de l'âme comprend de préférence :

- < 0,15 % en poids de Cr.

6. Feuille de brasage selon l'une quelconque des revendications 1 à 5, dans laquelle l'alliage de type 3xxx du doublage intermédiaire comprend de préférence :

- < 0,7 % en poids de Si et de manière plus préférée 0,4 % en poids de Si.

7. Feuille de brasage selon l'une quelconque des revendications 1 à 6, dans laquelle l'alliage de type 3xxx du doublage intermédiaire comprend de préférence :

- < 0,5 % en poids de Fe.

8. Feuille de brasage selon l'une quelconque des revendications 1 à 7, dans laquelle l'alliage de type 3xxx du doublage intermédiaire comprend de préférence :

   - < 0,2 % en poids de Cu.

9. Feuille de brasage selon l'une quelconque des revendications 1 à 8, dans laquelle l'alliage de type 3xxx du doublage intermédiaire comprend de préférence :

   - < 0,1 % en poids de Mg.

10. Feuille de brasage selon l'une quelconque des revendications 1 à 9, dans laquelle l'alliage de type 3xxx du doublage intermédiaire comprend de préférence : 0,5 à 3,0 % en poids de Zn.

11. Feuille de brasage selon l'une quelconque des revendications 1 à 10, dans laquelle la feuille de brasage comprend en outre un revêtement de brasage extérieur.

12. Feuille de brasage selon la revendication 11, dans laquelle il est prévu un autre doublage intermédiaire entre l'âme et le revêtement de brasage extérieur.

13. Feuille de brasage selon la revendication 11 ou 12, dans laquelle le revêtement de brasage intérieur et/ou le revêtement de brasage extérieur est fait d'un alliage de type 4xxx avec Si < 15 % en poids, de préférence Si < 14 à 15 % en poids et avec Cu < 0,3 % en poids.

14. Feuille de brasage selon l'une quelconque des revendications 1 à 13, dans laquelle les couches successives de la feuille de brasage présentent, par rapport à l'épaisseur totale de la feuille de brasage multicouche, les rapports d'épaisseur suivants :

revêtement extérieur	5 à 15 %
âme	60 à 85 %
doublage intermédiaire	5 à 30 %
revêtement intérieur	5 à 15 %

15. Assemblage brasé comprenant un ou plusieurs tubes réalisés à partir de la feuille de brasage multicouches selon l'une quelconque des revendications 1 à 13.

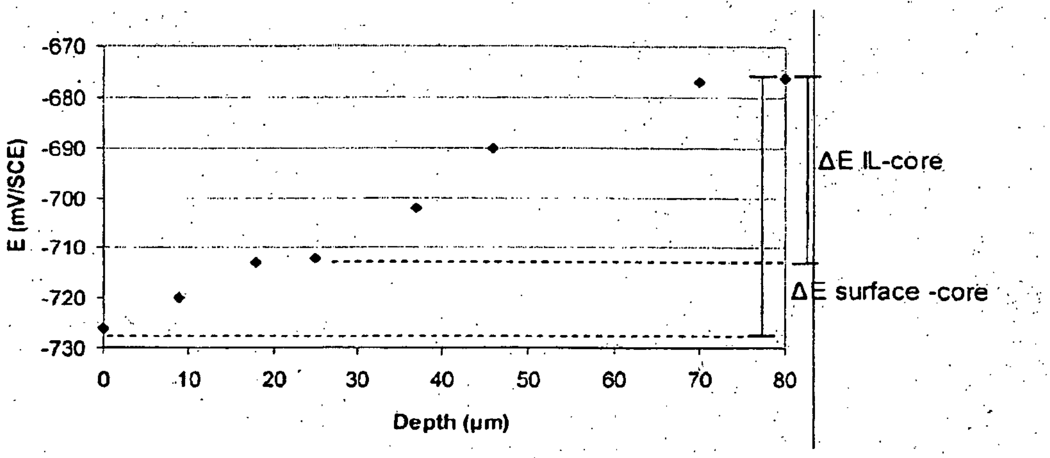

Figure 1: Corrosion potential profile for the material given in example 1

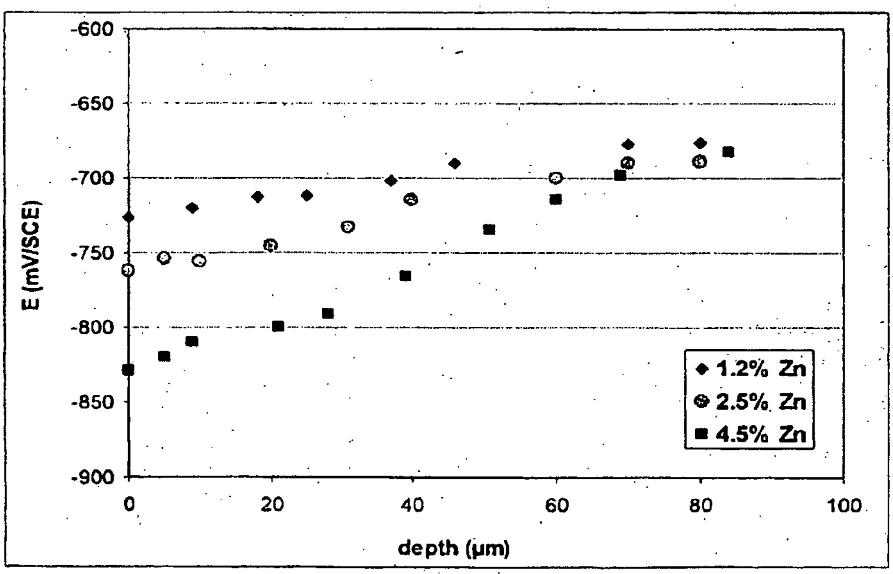

Figure 2: Corrosion potential profile for the materials given in example 2

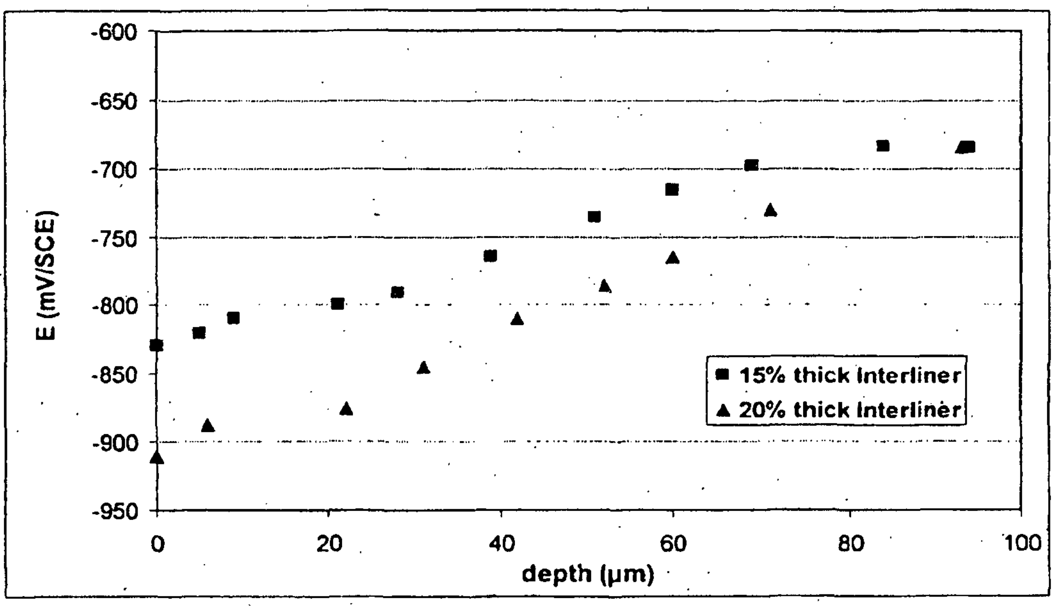

Figure 3: Corrosion potential profile for the materials given in example 3

REFERENCES CITED IN THE DESCRIPTION

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